Transplantation of Pediatric Donor Kidneys to Adult Recipients

Is There a Critical Donor Age?

KURT WENGERTER, M.D. VIVIAN A. TELLIS, M.D. ROBERT SOBERMAN, M.D.
ARTHUR J. MATAS, M.D. THERESA QUINN, P.A. FRANK J. VEITH, M.D.

Cadaver kidneys remain a scarce resource, yet single pediatric donor kidneys are underutilized at some centers. Between 1967 and 1984, 133 single pediatric and 318 adult donor cadaver transplants were performed. Patient and graft survival, renal function, and complications in adult recipients grouped by donor age were compared. Recipient age for all groups was similar (34–36 years). Life table analysis revealed no difference in graft survival in recipients of kidneys from donors aged 2, 3, 4, 5–10, and 11–15 when compared with adult donors. Graft survival in these groups improved over time with current 1-year survival over 75%. Recipients from donors less than 24 months of age demonstrated significantly poorer results, with no kidney surviving >2 months. Serum creatinine of grafts functioning >6 months was similar in all groups. It is concluded that single pediatric kidneys from donors greater than 2 years of age can be successfully transplanted to adults with good long-term results.

From the Department of Surgery, Montefiore Medical Center, New York, New York

CONCERN OVER functional capability, technical problems, and early graft loss have limited the transplantation of pediatric kidneys into adult recipients at some centers.[1–3] Others[4–7] have shown that a single pediatric kidney will grow and adequately sustain life in the adult. However, some authors[8,9] have advocated the transplant of both kidneys from pediatric donors to a single recipient to overcome some of the perceived problems. The continued shortage of kidneys for renal transplantation mandates continued efforts to determine the appropriate use of this pool of donor kidneys. We reviewed an 18-year experience with the transplantation of single pediatric donor kidneys to adults to determine if there exists a critical donor age associated with decreased graft function or survival.

Methods

From January 1967 to December 1984, 514 cadaveric donor renal allograft transplants were performed in adult recipients at Montefiore Medical Center. For the purpose of comparison with other studies, the term pediatric was defined as under age 16. During the period reviewed, 133 transplants were from the pediatric age group, while 381 were from donors aged 16 and over.

The transplanted kidneys were either harvested at our own institution or were procured through the New York Regional Transplant Program. The methods of organ preservation and recipient selection were similar for all patients. Operative technique was standard, including the use of a Carrel patch of the donor aorta for anastomosis to the recipient iliac artery. This was considered mandatory with the small pediatric donor vessels, and, in such cases where a sufficient amount of aorta was not available for a patch, the kidney was not used. Basic immunosuppression was achieved with prednisone and azathioprine, while rejection episodes were treated with intravenous methylprednisone and/or a course of antilymphocyte globulin.[10]

The transplant recipients were divided into four groups based on the age of the donor: I: 1–4 years; II: 5–10 years; III: 11–15 years; and IV: over 15 years. In addition, group I was further subdivided by years of age. The mean age of recipients in each group was calculated. Data from the earlier transplant years (1967–1979) were compared with those from later years (1980–1984). Computer-assisted actuarial analysis of patient and graft survival was determined.[11] Statistical significance of the differences in survival curves was calculated with the log-rank test.[12] In addition, long-term renal function, complications, and causes of graft failure were investigated and analyzed by the chi square test and Student's t-test where applicable.

Results

Of the 514 cadaveric renal transplants to adult recipients carried out during the period reviewed, 26% were

Reprint requests: Arthur J. Matas, M.D., Department of Surgery, Montefiore Medical Center, 111 East 210th Street, New York, NY 10467.
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TABLE 1. *Mean Recipient Age for Each Donor Age Group*

Donor Age Group	Donor Age Range (Years)	Recipients N (%)	Men Recipient age Years (±SD)
I	1–4	33 (6)	35 (12)
II	5–10	46 (9)	35 (10)
III	11–15	54 (11)	35 (9)
IV	Adult	381 (74)	36 (11)

TABLE 2. *Per Cent Patient Survival at 4 Years**

Donor Age Years	1967–1979 %	1980–1984 %	p Value of Difference†
1–4	43	100	<0.01
5–10	63	94	<0.1
11–15	66	94	<0.05
Adult	69	90	<0.001

* Patients transplanted between 1967 and 1979 are compared with those transplanted between 1980 and 1984.

† Log-rank test.

from pediatric donors, while 15% (79) were from donors aged 10 years or less and 6% (33) were from donors aged 4 or less (Table 1). The mean recipient age was not found to vary significantly among the groups (Table 1).

Four-year patient survival for the full period of review was found to range from a low of 69% (ages 1–4) to a high of 79% (adult), with no significant differences between the groups. In the earlier period (1967–1979), however, a significant difference ($p < 0.05$) did exist between the 4-year patient survival in recipients of kidneys from the youngest donor age group (43%) and recipients of adult kidneys (69%), with the other pediatric groups showing survival similar to the adult. In the later period (1980–1984), a marked improvement in all groups has been realized, with patient survival in each group more than 90% at 4 years (Table 2).

The life table graft survival for the full 18-year period of review is shown in Figure 1. No statistically significant differences in survival were present. Graft survival in the earlier period ranged from 23 to 33% at 4 years, and all groups showed improvement in the later period (Table 3). Calculation of the life table graft survival in the last 2 years of the study (1983 and 1984) shows continued improvement, with 1-year survival now over 75% for all patients. Further evaluation of graft survival and function in group I by year of age demonstrated markedly poorer results in the 6 recipients of kidneys from donors aged 1 year (mean: 16 months of age). None of the kidneys in this group survived beyond 2 months posttransplant, and the mean survival period was less than 1 month (Fig. 2). While graft survival in recipients of kidneys from the 1 year of age donor was significantly lower, survival in recipients of kidneys from donors aged 2 through 15 was similar to or better than survival in recipients of adult donor kidneys.

Renal function in the recipients of pediatric donor kidneys was compared with function in recipients of adult kidneys. Current serum creatinine level in all patients transplanted between 1980 and 1984 and who had functioning grafts with a minimum of 6 months of follow-up were reviewed. The serum creatinine in recipients of pediatric donor kidneys did not differ from that in adult kidney recipients (Table 4). The recipients of kidneys from the youngest donor age group had the lowest serum creatinine, but this difference was not statistically significant.

Chronic rejection was the most frequent cause of graft failure, responsible for 62% of all graft failures (Table 5), while acute rejection and primary nonfunction had somewhat lower incidences, 15 and 13%, respectively. Miscellaneous causes of graft failure included vascular and urologic complications, hyperacute rejection, sepsis, infarction, and withdrawal of medications (Table 5). Acute rejection as a cause of graft failure was higher in the 1–4 year donor age range when compared to the others, although the difference was not significant. Causes for graft failure in the 1-year donor group are included in Table 5 and are found to correspond to those for the adult.

The complication rate for the later period (1980–1984) was reviewed and found to be 17% for all patients (Table 6). The overall rate for the pediatric donor group (19%) was not significantly different than that for the adult (17%). However, a greater rate of urologic complications and renal artery stenosis was found in the pediatric group (Table 6), although again the differences were not statistically significant. In addition, these complications were treatable: of the four recipients of pediatric donor kidneys with renal

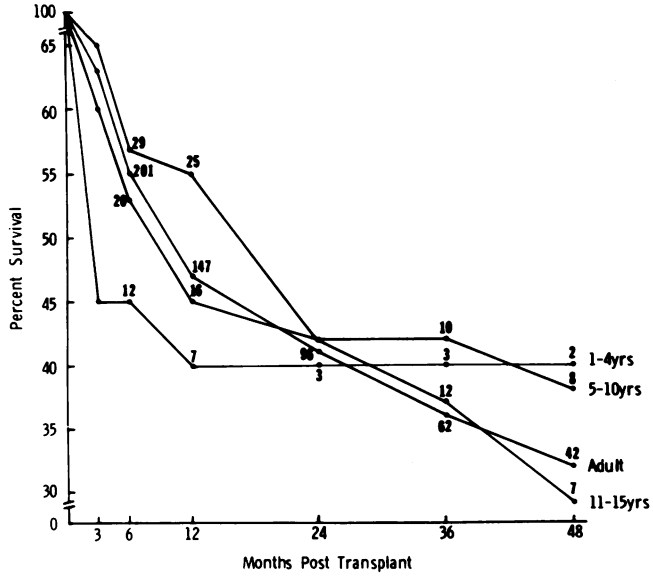

FIG. 1. Life table graft survival 1967–1984. Per cent graft survival in four donor age groups.

TABLE 3. *Per Cent Graft Survival at 1 and 4 Years Posttransplant**

Donor Age Years	1967–1979 1 Year %	1967–1979 4 Years %	1980–1984 1 Year %
1–4	32	32	55
5–10	37	33	53
11–15	50	23	59
Adult	35	23	63

* Earlier and later periods compared.

TABLE 4. *Mean Serum Creatinine in All Grafts at Least 6 Months from Transplant*

Donor Age Years	Number N	Mean Creatinine mg/dl (±SD)
2–4	10	1.6 (0.73)
5–10	8	2.0 (1.1)
11–15	14	2.1 (1.7)
Adults	85	1.9 (1.2)

artery stenosis (donor ages 4, 5, 6, and 13), all were successfully treated with percutaneous transluminal angioplasty, and all four kidneys are presently functioning with a mean serum creatinine of 2.2 mg/dl. A 13% complication rate was found in the 1–4 year donor group indicating that the recipients of the smaller pediatric kidneys did not have a disproportionate number of complications.

Discussion

Utilization of the pediatric donor kidney remains an unresolved issue. Almost 10 years ago Silbur[13] documented a rapid increase in renal size and function in rats when neonatal kidneys were transplanted into adults. This phenomenon of compensatory hypertrophy allows the pediatric donor kidney to achieve normal renal function in the adult recipient within weeks of the transplant. While most clinical studies have confirmed this finding, concern still exists that the smaller kidney must withstand the trauma of the donor harvest, storage, the transplant surgery itself, and possible rejection episodes with treatment, all prior to the completion of the hypertrophy. There are a number of reports in the literature addressing these issues. Kootstra[2] in 1978 reported on 24 pediatric donor recipients and demonstrated that while 1-year graft survival was equivalent to that in recipients of adult kidneys, pediatric kidney recipients more frequently required early postoperative dialysis.

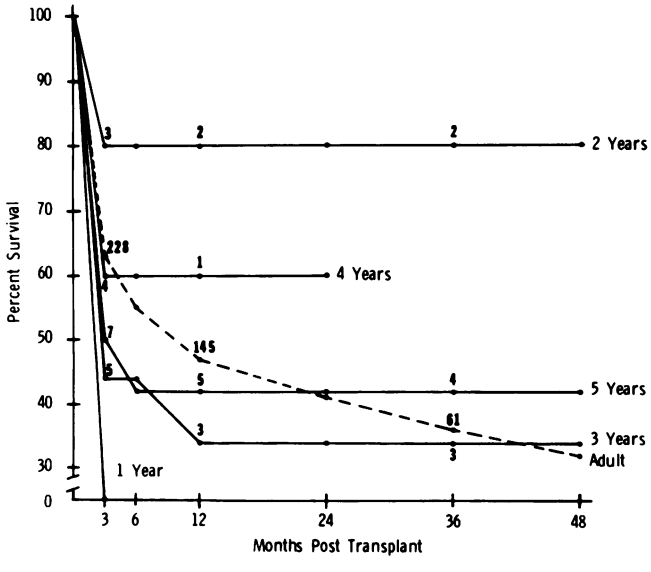

FIG. 2. Life table graft survival 1967–1984. Per cent graft survival by individual age of survivors under six *versus* adult.

Seven years ago Boczko et al.[4] from this institution reported on recipients of kidneys from donors less than 9 years of age. At that time it was concluded that the long-term graft survival was actually better with the pediatric donor kidney (32% compared to 15%), although the numbers were relatively small and a statistically significant difference was not found. The feasibility of using the pediatric donor kidney appeared to be confirmed by Glass et al.[5] in 1979 with a larger group of patients (N = 65). They found no statistically significant differences in the graft survival between recipients of pediatric and adult donor kidneys. However, in a later study from the same institution, Hong et al.[1] reported that graft survival in recipients of kidneys from donors less than 10 years of age was inferior. Specifically, none of nine kidneys from donors under 5 years of age survived more than 6 months when transplanted into adults. Managadze et al.[3] similarly found significantly poorer graft survival with pediatric donors. They reported a 1-year graft survival of 49% in recipients of kidneys from donors less than 16 years old *versus* 67% in recipients of kidneys from donors over 16. In addition, they had twice as many technical complications in the pediatric donor group. Graft loss in their study was early, and the difference in survival was established within the first 3 months posttransplant.

Our results clearly support the utilization of kidneys from donors greater than 24 months of age. We found an increase in graft loss only in recipients of kidneys from donors under 24 months. Current patient and graft survival in recipients of kidneys from donors aged 2–5 years, 6–10, or 10–15 was similar to that in recipients of adult kidneys. In view of our data, serious consideration should be given before a single kidney transplant is undertaken utilizing donors under 24 months of age. While 26% of our transplants were from donors in the pediatric age range (under 16 years), less than 1% of our transplants

TABLE 5. *Cause of Graft Failure in Each Donor Age Group (1967–1984)*

Donor Age Years	Number Failed N	Primary Nonfunction N (%)	Acute Rejection N (%)	Chronic Rejection N (%)	Miscellaneous N (%)
1	6	1 (17)	1 (17)	3 (50)	1 (17)
2–4	14	1 (7)	4 (29)	8 (57)	1 (7)
5–10	31	6 (19)	2 (6)	21 (68)	2 (6)
11–15	33	4 (12)	4 (12)	24 (73)	1 (3)
Adult	240	30 (13)	38 (16)	145 (60)	27 (11)
Total	324	42 (13)	49 (15)	210 (65)	32 (10)

were in this especially high-risk group. While complications such as renal artery stenosis and ureter leaks appeared more frequently in the recipients of pediatric kidneys, the differences were not significant and were not reflected in survival. In fact, complications such as renal artery stenosis may now be treated successfully with percutaneous angioplasty.

Recently, Schneider et al.[9] reported a 10-year experience with double pediatric cadaver donor renal transplants. Of the 21 double transplants, only three donors were aged 1 year or younger; six were aged 2 years; and 12 were between 3 and 10. The average donor age was 4.4 years. They found that the survival rate in this group was similar to that in a matched adult donor recipient group. Results were not compared to single pediatric donor recipients. Our results suggest that the use of double pediatric cadaver donors from the 2 years of age and older group is neither indicated nor justified. In this group, graft survival with single kidneys is comparable to survival with adult kidneys. Therefore, the use of double kidney transplants would reduce by 50% the number of transplants available from this group of donors. If only double transplants were performed at our institution for the 2–10 year donor age group, 73 fewer transplants would have been performed.

In summary, we have found that patient and graft survival with the transplantation of kidneys from donors 24 months of age or over is equivalent to that with adult donors. The notably poor results with single kidney transplantation from donors less than 24 months suggests that the double kidney approach warrants further consideration in this particular group.

TABLE 6. *Complications (1980–1984)*

Complication	Adult N = 170	Pediatric N = 54
Urologic	5 (2.9%)	3 (5.5%)
Renal artery stenosis	8 (4.7%)	4 (7.4%)
Miscellaneous*	15 (8.8%)	3 (5.6%)
Total	28 (16.5%)	10 (18.5%)

* Including infection, hemorrhage, infarction, lymphocele.

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